THE AQUATIC PLANT COMMUNITY FOR SHERWOOD LAKE ADAMS COUNTY 2006

I. INTRODUCTION

An updated aquatic macrophytes (plants) field study of Sherwood Lake was conducted during August 2006 by a staff member the Adams County Land and Water Conservatism Department and a staff member of the Tri-Lakes Management District. The first quantitative vegetation study was performed by Wisconsin Department of Natural Resources staff in 2000.

Information about the diversity, density and distribution of aquatic plants is an essential component in understanding the lake ecosystem due to the integral ecological role of aquatic vegetation in the lake and the ability of vegetation to impact water quality (Dennison et al, 1993). This study will provide information useful for effective management of Sherwood Lake, including fish habitat improvement, protection of sensitive areas, aquatic plant management, and water resource regulation. This data will be compared to the past and used future studies to offer insight into changes in the lake.

Ecological Role: Lake plant life is the beginning of the lake's food chain, the foundation for all other lake life. Aquatic plants and algae provide food and oxygen for fish and wildlife, as well as cover and food for the invertebrates that many aquatic organisms depend on. Plants provide habitat and protective cover for aquatic animals. They also improve water quality, protect shorelines and lake bottoms, add to the aesthetic quality of the lake, and impact recreation.

Characterization of Water Quality: Aquatic plants can serve as indicators of water quality because of their sensitivity to water quality parameters such as clarity and nutrient levels (Dennison et al, 1993).

Testing has shown that Sherwood Lake has very hard water. Lake water pH has ranged from 5.92 to 8.46. Hard water lakes tend to produce more fish and aquatic plants than soft water lakes.

Background and History: Sherwood Lake is located in the Town of Rome, Adams County, Wisconsin. The impoundment is slightly over 243 surface acres in size. Maximum depth is 24', with an average depth of 8'. During the summer of 2006 when this aquatic plant survey was conducted, the lake was at slightly lower level than usual due to drought and very hot weather. The dam impounds Fourteen-Mile Creek upstream from Arrowhead Lake and downstream from Camelot Lake dams, on its way to the Wisconsin River.

Sherwood Lake is accessible off of State Highway 13 by turning east onto Queens Way. There is a public boat launch on Sherwood Lake on the southwest edge of the lake owned by the Parks Department of Adams County. Heavy residential development around the lake is found along most of the lakeshore. The surface watershed is 31.73% residential48.08% woodlands; water; 6.73% open grassland and 13.46% water. The ground watershed, which extends into Waushara County, has much irrigated and non-irrigated agriculture, except near to the lakes. There are endangered or threatened resources in the watershed including the Karner Blue Butterfly, the Grassleaf Rush; the Yellow Screwstem, the Crossleaf Milkwort; and the natural communities of northern sedge meadow, northern wet forest, pine barrens and shrub carr. Archeological sites reported in the Sherwood Lake surface watershed include an unnamed burial site in the northern part of the watershed and the Bloody Nose Burial Mound south of the lake.

A fishery inventory in April 2002 revealed that yellow perch and largemouth bass are abundant in Sherwood Lake, while bluegills were common. Other fish, including walleye, black crappie and northern pike, were scarce. Stocking records of the Wisconsin Department of Natural Resources go back to 1968. Stocking started after a chemical fish kill in 1967 to remove rough fish. Through the years, the lake has been stocked with largemouth bass, walleye, northern pike, and bluegills.

Soils in the Sherwood Lake surface watershed are sands of various slopes. Such soils tend to be excessively-drained, with infiltration of water being rapid to very rapid, and permeability also high. Such soils also usually have a low water-holding and low organic matter content, thus making them difficult to establish vegetation on. These soils tend to be easily eroded by both water and wind.

Efforts at controlling aquatic plant growth have included both chemical treatments and mechanical harvesting.

Chemical Aquatic Plant Treatments in Sherwood Lake

Year	Copper (lbs)	Cutrine (gal)	Aquathol (gal)	Hydrothol (gal)	Diaquat (gal)	Rodeo (gal)	2,4-D (gal)	Silvex	AV-70
1970	250		10		5				
1971	305		17		14			3	
1972	293		9		20.5				
1973	620				12				
1974	1220				12		22		
1975	620		8.9		6.6		2		
1976	600		9.5		26				
1977	910		215	100	6				30
1978				550	8				8
1979	400								
1980	60			855					
1981	60			1200					
1982	450								
1983	500								
1984	200		27	1					
1985	70		56		8				
1986	900		38		6				
1987	430								
1988	605				6				
1989	50		7		5.5				
1990	400		20		22.5				
1991	200		3.5		18				
1992	250		10		8				
1993		15	9.5		10.5				
1994	360		17.5		10.5				
1995	425		13.25		5.25				
1996		32	14			14			
1997		72.5	2.5		2.5				
1999			6		6				
2000			35		35				
total	10178	119.5	528.65	2706	253.85	14	24	3	38

Both copper in pounds and cutrine in gallons added copper to Sherwood Lake. Copper is an element and does not degrade any further. Copper is known to harm native mollusks (clams, mussels, snails) and invertebrates that serve as food for the fish. Hydrothol, added to Sherwood Lake between 1977 and 1984, has been implicated in damage to young fish.

Mechanical harvesting of aquatic plants in Sherwood Lake started in 1995 and has continued through 2006. The chart below shows the pounds of aquatic plant removed through mechanical harvesting through 2006. For 2005 and 2006, plant samples were taken to a laboratory to be tested for the amount of phosphorus in milligrams per kilogram of aquatic plants. This is also shown on the chart below.

Mechanical Harvesting on Sherwood Lake		
Year	**Lbs Harvested**	**Phosphorus Removed (lbs)**
1995	58,000	NA
1996	204,000	NA
1997	340,000	NA
1998	195,600	NA
1999	317,000	NA
2000	652,000	NA
2001	496,000	NA
2002	491,600	NA
2003	519,000	NA
2004	582,000	NA
2005	709,200	2147.81
2006	307,500	117.83
	4,871,900	2,266

The aquatic plant survey in 2000 by the WDNR found that that the plant-like algae, *Chara* spp (muskgrass), was the most frequently-occurring aquatic "plant" species in Sherwood Lake. No aquatic plants occurred at more than 50% frequency. *Chara* spp also had the highest density. On the lake overall, no aquatic species occurred at more than average density, even where they were present. Of the two invasives, *Myriophyllum spicatum* (Eurasian watermilfoil) and *Potamogeton crispus* (Curly-Leaf Pondweed) found in 2000, *Myriphyllum spicatum* occurred at the highest density and frequency.

Since the discovery of zebra mussels in Arrowhead Lake, the WDNR has been monitoring Sherwood Lake for any sign of infestation. As of 2006, no zebra mussels had been found in Sherwood Lake.

II. METHODS

Field Methods

The 2000 and 2006 studies were both based on the rake-sampling method developed by Jessen and Lound (1962), using stratified random transects. The shoreline was divided into 19 equal sections, with one transect placed randomly within each segment, perpendicular to the shoreline. The same transects were used for both studies.

One sampling site was randomly chosen in each depth zone (0-1.5'; 1.5'-5'; 5'-10'; 10'-20') along each transect. Using long-handled, steel thatching rakes, four rake samples were taken at each site. Samples were taken from each quarter around the boat. Aquatic species present on each rake were recorded and given a density rating of 0-5.

A rating of 1 indicates the species was present on 1 rake sample.

A rating of 2 indicates the species was present on 2 rake samples.

A rating of 3 indicates the species was present on 3 rake samples.

A rating of 4 indicates the species was present on 4 rake samples.

A rating of 5 indicates that the species was abundantly present on all rake samples.

A visual inspection and periodic samples were taken between transects to record the presence of any species that didn't occur at the raking sites. Gleason and Cronquist (1991) nomenclature was used in recording species found.

Shoreline type was also recorded at each transect. Visual inspection was made of 50' to the right and left of the boat along the shoreline, 35' back from the shore (so total view was 100' x 35'). Percent of land use within this rectangle was visually estimated and recorded.

Data Analysis:

The percent frequency (number of sampling sites at which it occurred/total number of sampling sites) of each species was calculated. Relative frequency (number of species occurrences/total of all species occurrences) was also calculated. The mean density (sum of species' density rating/number of sampling sites) was calculated for each species. Relative density (sum of species' density/total plant density) was also calculated. "Mean density where present" (sum of species' density rating/number of sampling sites at which that species occurred) was calculated. Relative frequency and relative density results were summed to obtain a dominance value. Species diversity was measured by Simpson's Diversity Index.

The Average Coefficient of Conservatism and Floristic Quality Index were calculated as outlined by Nichols (1998) to measure plant community disturbance. A coefficient of Conservatism is an assigned value between 0 and 10 that measures the probability that the species will occur in an undisturbed habitat. The Average Coefficient of Conservatism is the mean of the coefficients for the species found in the lake. The Average Coefficient of Conservatism is used to calculate the Floristic Quality Index, a measure of a plant community's closeness to an undisturbed condition.

To measure the quality of the aquatic plant community, an Aquatic Macrophyte Index was determined using the method developed by Nichols et al (2000). This measurement looks at the following seven parameters and assigns each of them a number on a scale of 1-10: maximum depth of plant growth; percentage of littoral zone vegetated; Simpson's diversity index; relative frequency of submersed species; relative frequency of sensitive species; taxa number; and relative frequency of exotic species. The average total for the North Central Hardwoods lakes and impoundments is between 48 and 57.

III. RESULTS

Physical Data

The aquatic plant community can be impacted by several physical parameters. Water quality, including nutrients, algae and clarity, influence the plant community; the plant community in turn can modify these boundaries. Lake morphology, sediment composition and shoreline use also affect the plant community.

The trophic state of a lake is a classification of water quality (see Table 1). Phosphorus concentration, chlorophyll a concentration and water clarity data are collected and combined to determine a trophic state. **Eutrophic lakes** are very productive, with high nutrient levels and large biomass presence. **Oligotrophic lakes** are those low in nutrients with limited plant growth and small fisheries. **Mesotrophic lakes** are those in between, i.e., those which have increased production over oligotrophic lakes, but less than eutrophic lakes; those with more biomass than oligotrophic lakes, but less than eutrophic lakes; those with a good and more varied fishery than either the eutrophic or oligotrophic lakes.

The limiting factor in most Wisconsin lakes, including Sherwood Lake, is phosphorus. Measuring the phosphorus in a lake system thus provides an indication of the nutrient level in a lake. Increased phosphorus in a lake will feed algal blooms and also may cause excess plant growth. **The 2004-2006 summer average phosphorus concentration in Sherwood Lake was 41.06 ug/ml.** This is above the average for impoundments (30.0 mg/l). This concentration suggests that Sherwood Lake is likely to have several nuisance algal blooms, more than most impoundments. This places Sherwood Lake in the "fair" water quality section for impoundments, and in the "**mesotrophic**" level for phosphorus.

Chlorophyll a concentrations provide a measurement of the amount of algae in a lake's water. Algae are natural and essential in lakes, but high algal populations can increase water turbidity and reduce light available for plant growth. **The 2004-2006 summer average chlorophyll a concentration in Sherwood Lake was 21.86 ug/ml.** These chlorophyll a results place Sherwood Lake at the "**eutrophic**" level with "poor" water quality.

Water clarity is a critical factor for plants. If aquatic plants receive less than 2% of the surface illumination, they won't survive. Water clarity can be reduced by turbidity (suspended materials such as algae and silt) and dissolved organic chemicals that color or cloud the water. Water clarity is measured with a Secchi disk. **Average summer Secchi disk clarity in Sherwood Lake in 2004-2006 was 4.31'.** This is poor water clarity, putting Sherwood Lake into the "**eutrophic**" category with poor water clarity.

It is normal for all of these values to fluctuate during a growing season. They can be affected by human use of the lake, by summer temperature variations, by algae growth & turbidity, and by rain or wind events. Phosphorus tends to rise in early summer, than decline as late summer and fall progress. Chlorophyll a tends to rise in level as the water warms, then decline as autumn cools the water. Water clarity also tends to decrease as summer progresses, probably due to algae growth, then decline as fall approaches.

Table 1: Trophic States

Trophic State	Quality Index	Phosphorus	Chlorophyll a	Sechhi Disk
		(ug/ml)	(ug/ml)	(ft)
Oligotrophic	Excellent	<1	<1	>19
	Very Good	1 to 10	1 to 5	8 to 19
Mesotrophic	Good	10 to 30	5 to 10	6 to 8
	Fair	**30 to 50**	10 to 15	5 to 6
Eutrophic	Poor	50 to 150	**15 to 30**	**3 to 4**
Sherwood Lake		**41.06**	**21.86**	**4.31'**

According to these results, Sherwood Lake scores as **"mesotrophic"** in phosphorus readings of the general parameters often used to gauge lake water, but **"eutrophic"** in the other two parameters. With such readings, dense plant growth and frequent algal blooms would be expected.

A groundwater study done in 2000 by UW-Stevens Point staff found that Sherwood Lake had the most aquatic macrophytes of all the Tri-Lakes. The study further noted that Sherwood Lake gained water from the groundwater, but that the groundwater coming into Sherwood Lake came with elevated reactive phosphorus and ammonium, suggesting nutrient inputs from around the lake (rather than from the upper watershed). This phenomenon, i.e., nutrients being drawn into the lake by the groundwater entering the lake, was increased during the traditional winter drawdowns of the lake. This study indicated that internal phosphorus loading is probably occurring in Sherwood Lake, which increases the likelihood of aquatic plant growth and algae occurrence.

Lake morphology is an important factor in distribution of lake plants. Duarte & Kalff (1986) determined that the slope of a littoral zone could explain 72% of the observed variability in the growth of submerged plants. Gentle slopes support higher plant growth than steep slopes (Engel 1985).

Sherwood Lake is a horseshoe-shaped narrow lake that lies in the middle of a series of lakes that are originally fed by a very large, multi-county stream system. Both Upper and Lower Camelot Lakes flow into Sherwood Lake. Much of the lake is shallow, although there are some areas of steeper drop-offs within the lake near the dam. With poor water clarity and shallow depths, plant growth might normally not be favored in much of Sherwood Lake, but evaluations of aquatic plant growth have shown that such growth is abundant in Sherwood Lake, despite the poor water clarity.

Sediment composition can also affect plant growth, especially those rooted. The richness or sterility and texture of the sediment will determine the type and abundance of macrophyte species that can survive in a particular location.

Table 2: Sediment Composition—Sherwood Lake

		Zone 1	Zone 2	Zone 3	Zone 4	Overall
	Rock	6.30%				1.63%
Hard	Sand	78.13%	83.33%	75.00%	73.68%	78.05%
Sediments	Sand/Cobble	3.12%				0.81%
	Sand/Gravel		2.78%			0.81%
	Sand/Rock	6.30%	2.78%			2.44%
Mixed	Sand/Muck		5.56%	22.22%	26.32%	12.20%
Sediments	Sand/Silt	3.12%				1.63%
Soft						
Sediments	Muck	3.12%	2.78%	2.78%		2.44%

Most of the sediment in Sherwood Lake is hard, with little natural fertility and low available water holding capacity. Although such sediment may limit growth, most hard sediment sites in Sherwood Lake were vegetated. 84.6% sample sites were vegetated in Sherwood Lake, no matter what the sediment. Some of the unvegetated sites appeared to have had vegetation cleared by hand harvesting.

Shoreline land use often strongly impacts the aquatic plant community and thus the entire aquatic community. Impacts can be caused by increased erosion and sedimentation and higher run-off of nutrients, fertilizers and toxins applied to the land. Such impacts occur in both rural and residential settings.

Some type of native vegetated shoreline covered only 21.46% of the lake shoreline in 2006, down from 30% in 2000. Disturbed shorelines—including bare sand, traditional cultivated lawn, hard structure (piers, decks, seawalls, etc.) and rock riprap--were the most frequently-occurring shore, covering 78.54% of the shore of Sherwood Lake in 2006, increased from 70% of the shore in 2000.

Table 3: Shoreland Land Use—Sherwood Lake—2000 and 2006

		2006 Frequency	2000 Frequency	2006 Coverage	2000 Coverage
Vegetated	Herbaceous	50.00%	25.00%	11.55%	5.97%
Shoreline	Shrub	19.44%	27.78%	2.69%	6.53%
	Wooded	27.78%	36.11%	7.22%	17.50%
Disturbed	Bare Sand/Eroded	25.00%	44.45%	3.61%	14.72%
Shoreline	Cultivated Lawn	80.56%	77.78%	49.88%	48.19%
	Hard Structure	83.33%	38.89%	17.69%	2.50%
	Pavement/Cement	19.45%	5.56%	2.22%	0.28%
	Rock/Riprap/Gravel	38.89%	16.67%	5.14%	4.03%

Macrophyte Data

SPECIES PRESENT

Of the 29 species found in Sherwood Lake, 25 were native and 4 were exotic invasives. In the native plant category, 14 were emergent, 1 was a free-floating plant, and 10 were submergent species. Four exotic invasives, *Myriophyllum spicatum* (Eurasian Watermilfoil), *Nasturtium microphyllum* (watercress), *Phalaris arundinacea* (Reed Canarygrass), and *Potamogeton crispus* (Curly-Leaf Pondweed) were found.

Comparing the species found in 2006 to those reported in 2000, some changes are evident. Several plants found in 2006 were not found in 2000, especially emergents: *Carex crawfordii* (emergent); *Carex comosa* (emergent); *Eupatorium purpureum* (emergent); *Hypericum canadense* (emergent); *Iris versicolor* (emergent); *Lathyris palustris* (emergent); *Potamogeton illinoensis* (submergent); *Rancunculus recurvatus* (emergent); *Salix spp* (emergent); and *Scirpus validus* (emergent).

Table 4—Plants Found in Sherwood Lake, 2006

Scientific Name	Common Name	Type	Found in 2000
Calamagrostis canadensis	Blue-Joint Grass	Emergent	
Carex crawfordii	Crawford's Sedge	Emergent	
Carex comosa	Longhair Sedge	Emergent	
Ceratophyllum demersum	Coontail	Submergent	x
Chara spp	Muskgrass	Submergent	x
Eupatorium purpureum	Sweetscented Joe Pye Weed	Emergent	
Hypericum canadense	Large St. John's Wort	Emergent	
Iris versicolor	Blue-Flag Iris	Emergent	
Juncus spp	Rush	Emergent	x
Lathyris palustris	Marsh Pea	Emergent	
Lemna minor	Small Duckweed	Free-Floating	x
Myriophyllum sibiricum	Northern Milfoil	Submergent	x
Myriophyllum spicatum	Eurasian Watermilfoil	Submergent	x
Najas flexilis	Bushy Pondweed	Submergent	x
Nasturtium microphyllum	Watercress	Floating-Leaf	
Phalaris arundinacea	Reed Canarygrass	Emergent	
Potamogeton crispus	Curly-Leaf Pondweed	Submergent	x
Potamogeton illinoensis	Illinois Pondweed	Submergent	
Potamogeton pectinatus	Sago Pondweed	Submergent	x
Potamogeton pusillus	Small Pondweed	Submergent	x
Potamogeton zosteriformis	Flat-Stem Pondweed	Submergent	x
Renaunculus recurvatus	Hooked Buttercup	Emergent	
Sagittaria spp	Arrowhead	Emergent	x
Salix spp	Willow	Emergent	
Scirpus validus	Soft-Stem Bulrush	Emergent	
Thelypteris palustris	Marsh Fern	Emergent	
Typha latifolia	Wide-Leaf Cattail	Emergent	x
Vallisneria americana	Water Celery	Submergent	x
Zosterella dubia	Water Stargrass	Submergent	x

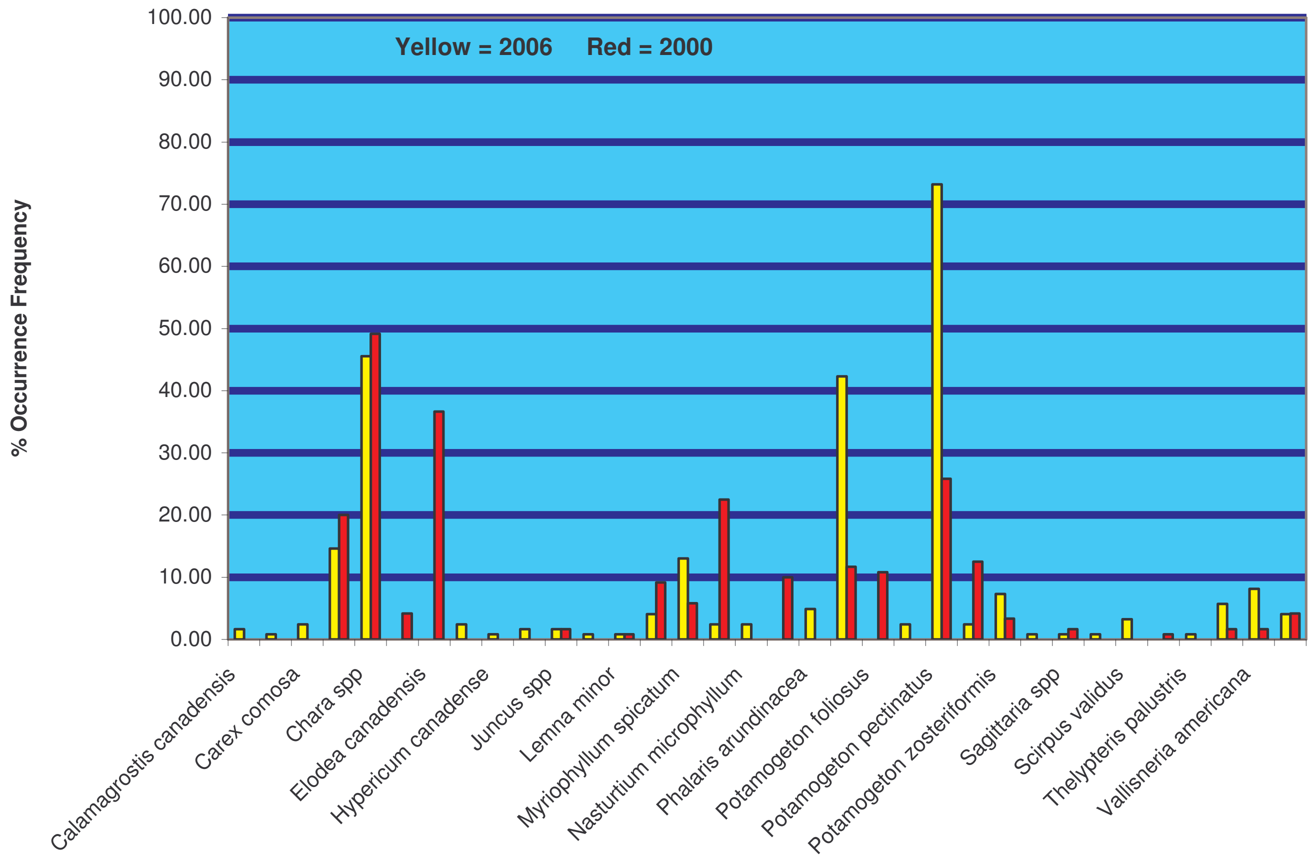
Of the plants on this list, several are species likely to increase in frequency and/or density in the case of regular drawdowns: *Lemna minor* (free-floating);

Najas flexilis (submergent); *Potamogeton crispus* (submergent exotic); *Potamogeton pectinatus* (submergent); *Scirpus validus* (emergent) and *Potamogeton zosteriformis* (submergent). Some also tend to decrease with regular drawdowns: *Chara* spp (submergent); *Myriophyllum sibiricum* (submergent); *Myriophyllum spicatum* (submergent exotic); and *Vallisneria americana* (submergent). In general, regular drawdowns will tend to encourage the increase of plants that can survive frequent disturbances and will also tend to reduce the diversity of the aquatic plant community

FREQUENCY OF OCCURRENCE

Potamogeton pectinatus, an aquatic plant favored by drawdowns, was the most frequently-occurring plant in Sherwood Lake in 2006. In 2000, the most frequent species was *Chara* spp. No species but *Potamogeton pectinatus* reached a frequency of 50% or greater in the lake overall in 2006, although *Chara spp* and *Potamogeton crispus* were not far under 50%, with occurrence frequencies of 45.53% and 42.28% respectively. In 2000, no aquatic species reached an overall occurrence frequency of over 50%.

Chart 1: Occurrence Frequency



Filamentous algae were found at 22.76% of the sample sites in 2006 and at 38.33% of the sites in 2000.

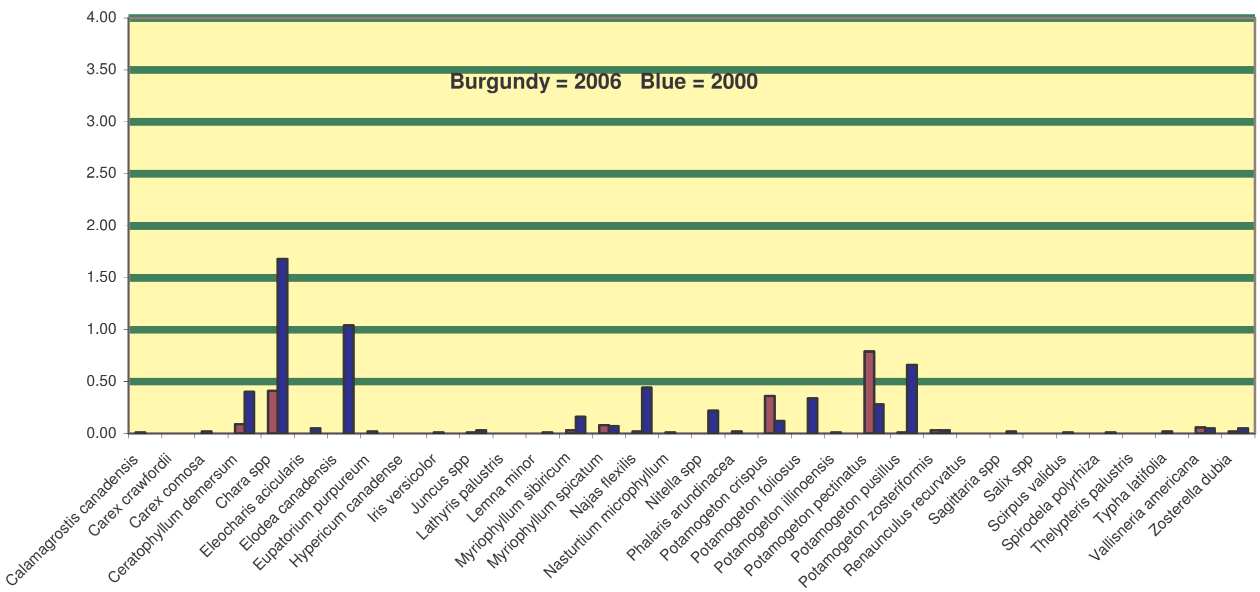
DENSITY OF OCCURRENCE

Potamogeton pectinatus was also the densest plant in 2006 in Sherwood Lake. In the lake overall, none of the aquatic plant species had a mean density of over 2.0, meaning none occurred at more than average, in 2006. In 2006, the only species occurring at more than average density in any of the depth zones was

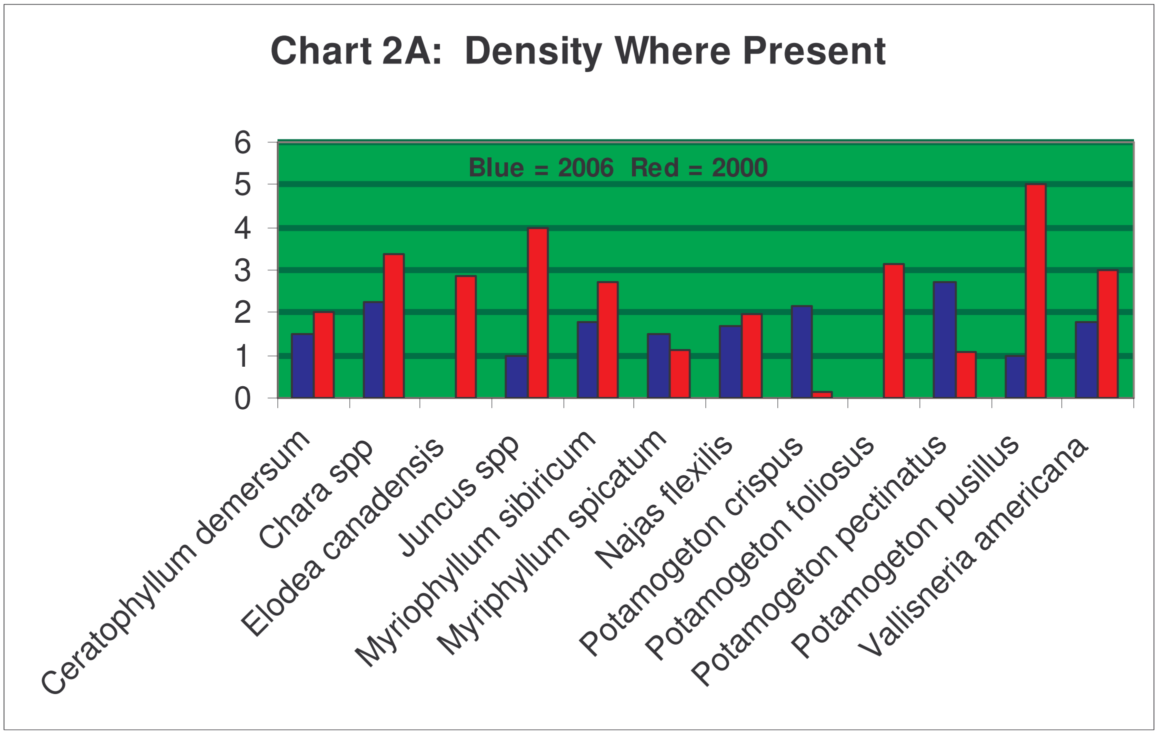
Potamgeton pectinatus in the second (1.5’-5’) and third (5’-10’) depth zones. Densest in Depth Zone 1 was *Chara spp*; densest in the other three zones was *Potamogeton pectinatus.*

No species occurred at more than average density in the lake overall in 2000, either. The only depth zone with more than average density of growth was Depth Zone 3, where *Chara spp* grew at more than average density.

Chart 2: Density in 2006 & 2000

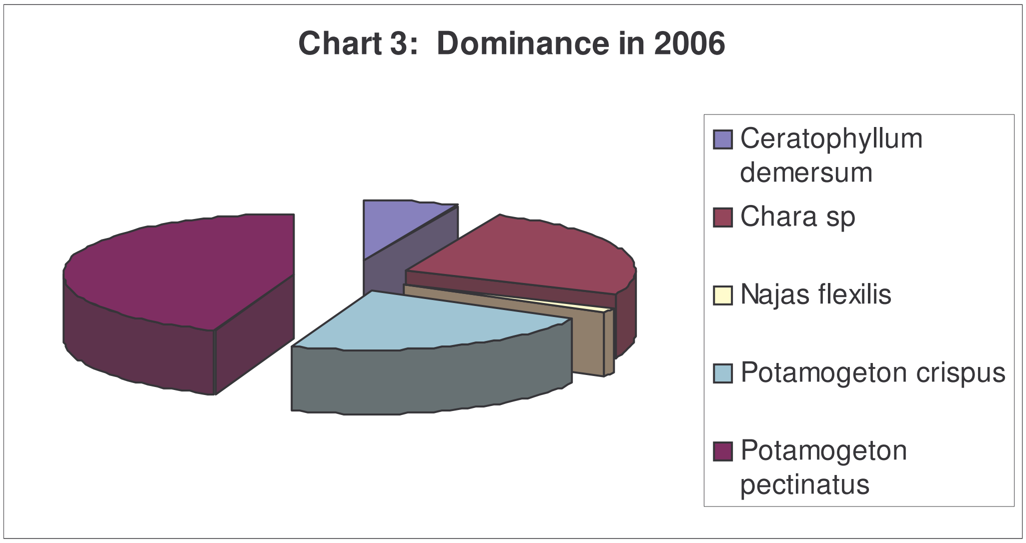


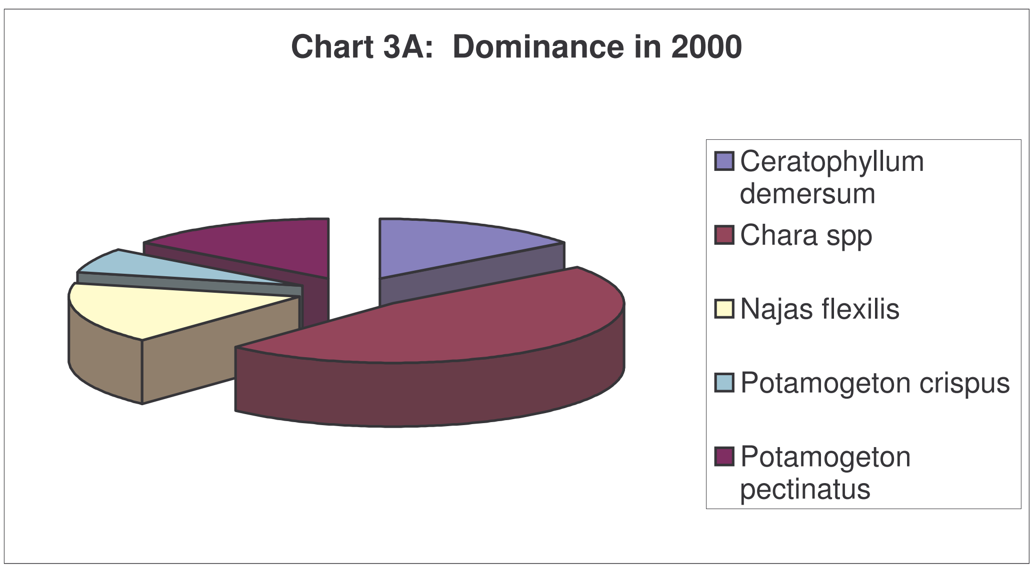
However, when looking at the “mean density where present”, three plants in addition to *Potamogeton pectinatus* had a more than average “density where present” in 2006: *Chara spp; Eupatorium purpureum;* and *Potamogeton crispus.* This is lower than the seven species beside *Chara* spp that had more than average “density where present” in 2000: *Elodea canadensis; Juncus spp; Myriophyllum sibiricum; Nitella spp; Potamogeton foliosus; Potamogeton pusillus* and *Vallisnera americana.* These figures indicate some species in the lake have higher than average density that can interfere with fish habitat and recreational use.



DOMINANCE

Relative frequency and relative density are combined into a dominance value that demonstrates how dominant a species is within its aquatic plant community. Based on dominance value, *Chara* spp was the dominant aquatic "plant" species in Sherwood Lake in 2000. Sub-dominant was *Elodea canadensis.* However, in 2006, *Potamogeton pectinatus* dominated the aquatic plant community, with *Potamogeton crispus* and *Chara* spp next most dominant. The exotics found Sherwood Lake, were not present in high frequency, high density or high dominance in either year although *Myriophyllum spicatum* had a greater frequency in 2000.





In 2006, *Potamogeton pectinatus* was dominant in Depth Zones 1 and 2, with *Chara* spp subdominant in each. *Potamogeton pectinatus* also dominated in Depth Zone 3, with *Potamgeton crispus* and *Erataphyllum demersum* subdominant. *Potamgeton pectinatus* dominated Depth Zone 4 in 2006. In 2000, *Chara* spp dominated all four depth zones.

DISTRIBUTION

Aquatic plants occurred at 84.6% of the sample sites in Sherwood Lake to a maximum rooting depth of 14'. This increased coverage from the 79.2% figure of 2000, when the maximum rooting depth was 12'. Filamentous algae were found in the three shallowest zones in both 2006 and 2000.

Secchi disc readings are used to predict maximum rooting depth for plants in a lake (Dunst, 1982). Based on the summer 2004-2006 Secchi disc readings, the predicted maximum rooting depth in Sherwood Lake would be **7.98 feet.** During both the 2000 and the 2006 aquatic plant surveys, rooted plants were found at a depth of **14'**, i.e., rooted plants were at a depth substantially more than that to be expected by Dunst calculations.

In 2006, the 1.5-5' depth zone (Zone 2) produced the highest total occurrence of plant growth, followed closely by Depth Zone 3. There was then a slight drop in occurrence to Zone 1, then a sharp drop to Zone 4. The pattern was slightly different in 2000: Depth Zone 3 had the highest total occurrence, then a drop in frequency in Depth Zone 2. Depth Zone 1 was lower than Depth Zone 2, with Zone 4 having the lowest total occurrence of all.

For plant density in 2006, Depth Zone 2 had the greatest total density, with Depth Zone 3 having slightly less. A sharp drop in density characterized Depth Zone 1 and even lower to Depth Zone 4. In 2000, the same pattern was followed.

Chart 4: Zone Occurrence

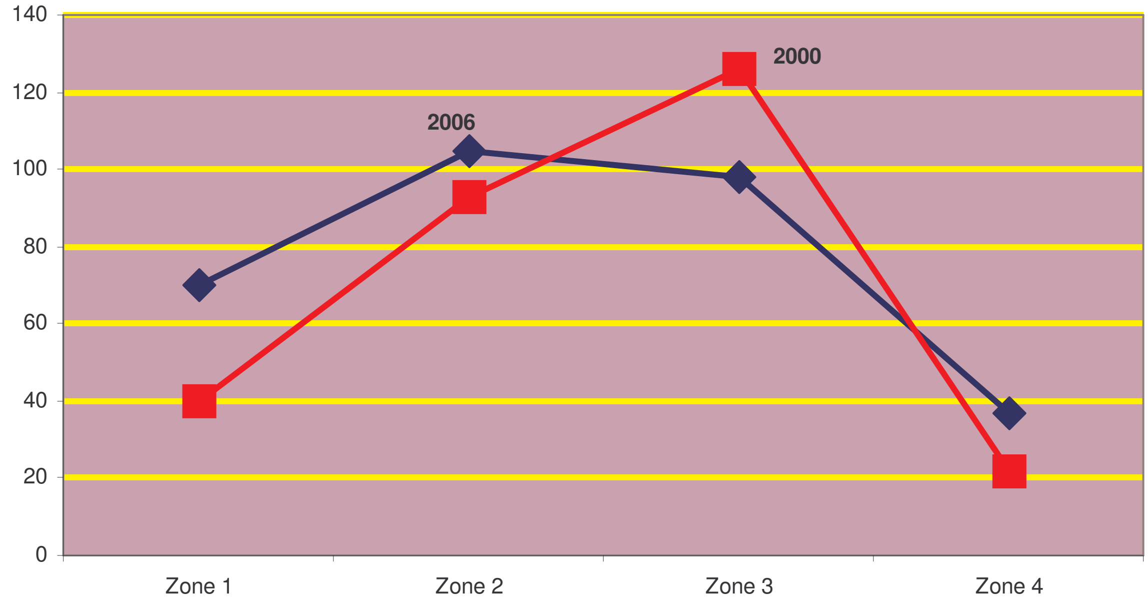
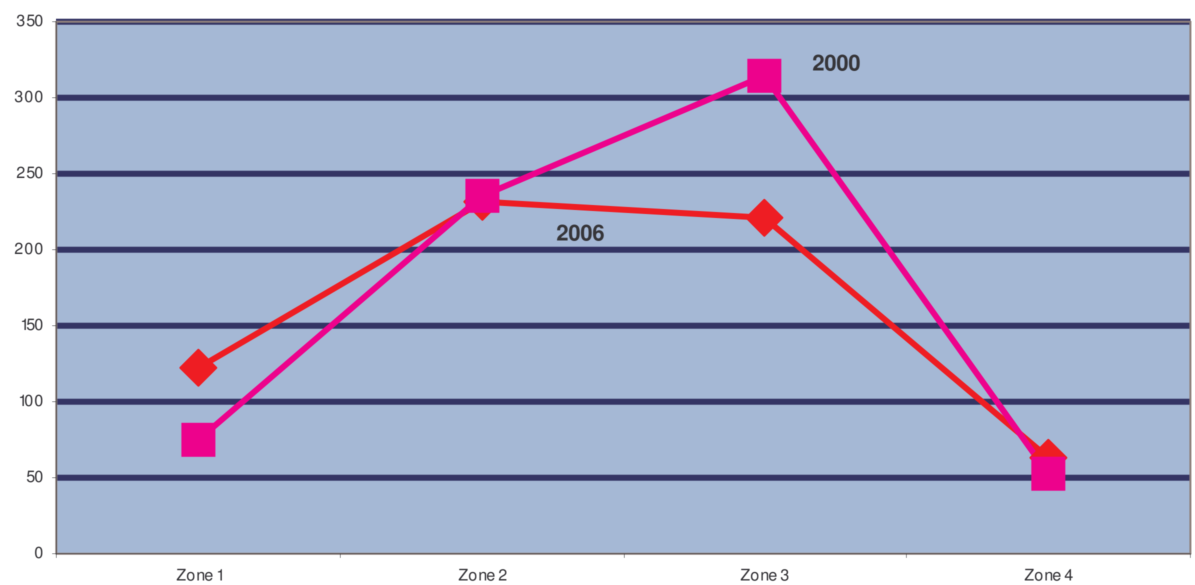


Chart 5: Zone Density



Species richness increased slightly between 2000 and 2006, with the biggest increase in richness found in Depth Zone 1 (0-1.5').

	2006	2000
Zone 1	5.38	2.35
Zone 2	2.94	2.58
Zone 3	2.8	3.56
Zone 4	1.95	1.69
Overall	2.98	2.93

THE COMMUNITY

The Simpson's Diversity Index for Sherwood Lake in 2006 was .84, indicating poor species diversity. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable). This places it in the lowest quartile for Simpson's Diversity Index readings for both North Central Hardwood Forest and all Wisconsin lakes. This is lower than the Simpson's Diversity Index for 2000, which was .89. The 2006 AMCI for Sherwood Lake is 49, placing its quality below the average for North Central Wisconsin Lakes and all Wisconsin Lakes. The AMCI value for 2000, 47, is also below average range for quality of aquatic plant community.

Table 5: Aquatic Macrophyte Community Index-2006 & 2000

AMCI Category	2006 Result	2006 Value	2000 Result	2000 Value
Max. Rooting Depth	14'	8	12'	6
% Littoral Zone Veg.	84.6%	10	79.2%	10
% Submersed Species	88%	9	95%	6
% Exotic Species	24%	3	8%	4
% Sensitive Species	4%	4	6%	5
Taxa #	23	9	16	8
Simpson's Index	0.84	6	0.89	8
		49		47

Using the AMCI index, some change has occurred in Sherwood Lake between 2000 and 2006, not necessarily for the better.

The presence of four invasive, exotic species could be a significant factor in the future. In 2006, *Potemogeton crispus* had the highest occurrence of any of the exotics found in Sherwood Lake, but *Myriophyllum spicatum* had an occurrence frequency of over 13% in 2006, despite the long history of both chemical and mechanical control efforts and despite this plant survey being done early in the summer, before some *M. spicatum* has reached its maximum growth. These plants must continue to be monitored, since their tenacity and ability to spread to large areas fairly quickly could make them a danger to the already low diversity of Sherwood Lake's current aquatic plant community.

The Average Coefficient of Conservatism and Floristic Quality Index calculation were performed on the field results. Technically, the Average Coefficient of Conservatism measures the community's sensitivity to disturbance, while the Floristic Quality Index measures the community's closeness to an undisturbed condition. Indirectly, they measure past and/or current disturbance to the particular community.

Previously, a value was assigned to all plants known in Wisconsin to categorize their probability of occurring in an undisturbed habitat. This value is called the plant's Coefficient of Conservatism. A score of 0 indicates a native or alien opportunistic invasive plant. Plants with a value of 1 to 3 are widespread native plants. Values of 4 to 6 describe native plants found most commonly in early successional ecosystem. Plants scoring 6 to 8 are native plants found in stable climax conditions. Finally, plants with a value of 9 or 10 are native plants found in areas of high quality and are often endangered or threatened. In other words, the lower the numerical value a plant has, the more likely it is to be found in disturbed areas.

The Average Coefficient of Conservatism in Sherwood Lake in 2006 was 4.6, up slightly from 4.00 in 2000. This puts this lake in the lowest quartile for Wisconsin Lakes (average 6.0) and for lakes in the North Central Hardwood Region (average 5.6). The aquatic plant community in Sherwood Lake is in the category of those very tolerant of disturbance, probably due to selection by a series of past disturbances and heavy shoreline development.

The Floristic Quality Index of the aquatic plant community in Sherwood Lake of 16.85 in 2006 is in the lowest quartile for Wisconsin Lakes and the North Central Hardwood Region. This suggests that the plant community in Sherwood Lake is within the group of lakes farthest from an undisturbed condition in Wisconsin overall and in the North Central Hardwood Region. The 2000 figure of 16.97 was also in the lowest quartile. The Floristic Quality Index has decreased slightly between 2000 and 2006, suggesting more disturbance progress to the lake. Using either the Average Coefficient of Conservatism or the Floristic Quality Index scales, the aquatic plant community in Sherwood Lake apparently has been impacted by a high amount of disturbance.

"Disturbance" is a term that covers many disruptions to a natural community. It includes physical disturbances to plant beds such as boat traffic, plant harvesting, chemical treatments, dock and other structure placements, shoreline development and fluctuating water levels. Indirect disturbances like sedimentation, erosion, increased algal growth, and other water quality impacts will also negatively affect an aquatic plant community. Biological disturbances such as the introduction of non-native and/or invasive species (such as the Eurasian Watermilfoil, Reed Canarygrass and Curly-Leaf Pondweed found here), destruction of plant beds, or changes in aquatic wildlife can also negatively impact an aquatic plant community. Shore development and sediment deposition can also reduce the quality of the aquatic plant community.

Out of the 36 transects sampled on Sherwood Lake, only one site was entirely naturally vegetated. Therefore, no statistical evaluation comparing the aquatic macrophyte communities at disturbed vs. natural shores was appropriate.

IV. DISCUSSION

Based on water clarity, chlorophyll and phosphorus data, Sherwood Lake is a eutrophic/mesotrophic impoundment with poor water clarity and fair to poor water quality. This trophic state should support substantial plant growth and several algal blooms.

Sufficient nutrients (trophic state), shallow lake, and nutrient input from heavy shore development on Sherwood Lake favor plant growth. Despite the sometime limiting effect of poor water clarity and sand sediments on aquatic plant growth, over 84% of the lake is vegetated, suggesting that even the heavily-sandy sediments in Sherwood Lake hold sufficient nutrients to maintain aquatic plant growth.

Historically, many aquatic plant treatments in Sherwood Lake were chemical. There has been mechanical harvesting to try to reduce plant growth in the last 10 years or so. A continued regular schedule and pattern of machine harvesting will help in removing vegetation from the lake and may help with nutrient reduction. The harvesting should also be designed to set back the growth of Eurasian Watermilfoil and Curly-Leaf Pondweed, not spread them further. It might also help to skim off the filamentous algae.

The lake has some mixture of structure of emergent and submerged plants. Of the 29 species found in Sherwood Lake, 25 were native and 4 were exotic invasives. In the native plant category, 14 were emergent, 1 was a free-floating plant, and 10 were submergent species. Three exotic invasives, *Myriophyllum spicatum* (Eurasian Watermilfoil), *Nasturnum microphyllum* (watercress), *Phalaris arundinacea* (Reed Canarygrass), and *Potamogeton crispus* (Curly-Leaf Pondweed) were found.

Potamogeton pectinatus, an aquatic plant favored by drawdowns, was the most frequently-occurring plant in Sherwood Lake in 2006. In 2000, it was *Chara* spp. No species but *Potamogeton pectinatus* reached a frequency of 50% or greater in the lake overall in 2006, although *Chara* spp and *Potamogeton crispus* were not far under 50%, with occurrence frequencies of 45.53% and 42.28% respectively. In 2000, no aquatic species reached an overall occurrence frequency of over 50%.

Potamogeton pectinatus was also the densest plant in 2006 in Sherwood Lake. In the lake overall, none of the aquatic vegetation had a mean density of over 2.0, meaning none occurred at more than average, in 2006. In 2006, the only species occurring at more than average density in any of the depth zones was *Potamgeton pectinatus* in the second (1.5’-5’) and third (5’-10’) depth zones. Densest in Depth Zone 1 was *Chara spp*; densest in the other three zones was *Potamogeton pectinatus.* These figures indicate some areas of the lake species with have higher than average aquatic plant density that can interfere with fish habitat and recreational use.

Total plant occurrence and total density decreased in the 5’-10’ depth from 2000 to 2006. This may be due to the new harvesting plan.

The very few shore areas of natural vegetation and wetlands on the lake should be preserved as they are to maintain habitat and to serve as a buffer for that area. Studies have suggested that runoff from naturally-buffered land is substantially less than that of developed areas. There are also some areas of deep erosion on steep banks that need to be addressed to prevent tree fall (and related root ball removal from bank) and bank preservation. Shoreline restoration of native vegetation is badly needed on Sherwood Lake and has actually decreased since 2000.

Some type of native vegetated shoreline covered only 21.46% of the lake shoreline in 2006, down from 30% in 2000. Disturbed shorelines—including bare sand, traditional cultivated lawn, hard structure (piers, decks, seawalls, etc.) and rock riprap--were the most frequently-occurring shore, covering 78.54% of the shore of Sherwood Lake in 2006, up from 70% of the shore in 2000.

The Simpson's Diversity Index Sherwood Lake in 2006 was .84, an indication of poor species diversity. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable). This places it in the lowest quartile for Simpson's Diversity Index readings for both North Central Hardwood Forest and all Wisconsin lakes. The 2006 AMCI for Sherwood Lake is 49, placing its quality below average for North Central Wisconsin Lakes and all Wisconsin Lakes.

Looking at the results from the 2000 survey and those from 2006 shows some changes in the aquatic plant community. There were more species found in 2006, and the structure of the aquatic plant community has changed with more emergent species present, but only one free-floating plant. No floating-leaf plants, which provide habitat and cover for fish and invertebrates, were found in either year.

Changes in the Aquatic Plant Community 2000 to 2006

	Changes in the Macrophyte Community			
sherwood	2000	2006	Change	%Change
Number of Species	18	25	7	**38.89%**
Maximum Rooting Depth	12.0	14.0	2	**16.67%**
% of Littoral Zone Unvegetated	20.80%	15.40%	-0.054	-25.96%
%Emergents	5.26%	12.50%	0.1	**137.64%**
%Free-floating	2.11%	0.00%	0.0	-100.00%
%Submergents	100.00%	100.00%	0.0	0.00%
%Floating-leaf	0.00%	0.00%	0.0	0.00%
Simpson's Diversity Index	0.89	0.84	-0.05	-5.51%
Species Richness	3.72	2.94	-0.78	-20.97%
Floristic Quality Index	16.97	16.85	-0.12	**-0.71%**
Average Coefficient of Conservatism	4	4.6	0.60	**15.00%**
AMCI Index	47	49	2.00	**4.26%**

Further, when calculating the coefficient of similarity between the 2000 and 2006 surveys, they score as statistically dissimilar both in terms of frequency of occurrence and relative frequency. Based on frequency of occurrence, the aquatic plant communities of the two years are just over 45% similar. Using relative frequency, the score is only 53% similar. Similarity percentages of 75% or more are considered statistically similar. Obviously, the figures for Sherwood Lake are far below that figure.

It is worth noting that the report on the 2000 aquatic plant surveys mentioned the low level of emergent plants in Sherwood Lake. The 2006 survey shows that emergent plants are were still scarce in Sherwood Lake than they were in 2000, but there were more increased coverage from emergent plants in 2006.

	Changes in Aquatic Plant Species				
Species		2000	2006	Year1-2	% Change
Ceratophyllum demersum	Frequency	9.0%	6.0%	-0.03	-33.3%
	Mean Density	0.40	0.09	-31.00%	-77.5%
	Dom. Value	0.16	0.10	-0.06	-37.5%
Chara	Frequency	21.0%	18.0%	-0.03	-14.3%
	Mean Density	1.66	0.41	-1.25	-312.5%
	Dom. Value	0.51	0.38	-0.13	-25.5%
Myriophyllum sibiricum	Frequency	4.0%	2.0%	-0.02	-50.0%
	Mean Density	0.16	0.03	-0.13	-81.3%
	Dom. Value	0.05	0.03	-0.02	-40.0%
Myriophyllum spicatum	Frequency	3.0%	5.0%	0.02	66.7%
	Mean Density	0.07	0.08	0.01	14.3%
	Dom. Value	0.04	0.09	0.05	125.0%
Najas flexilis	Frequency	10.0%	1.0%	-0.09	-90.0%
	Density	0.44	0.02	-0.42	-95.5%
	Dom. Val.	0.18	0.02	-0.16	-88.9%
Potamogeton crispus	Frequency	5.0%	17.0%	0.12	240.0%
	Density	0.12	0.36	0.24	200.0%
	Dom. Val.	0.07	0.34	0.27	385.7%

Potamogeton pectinatus	Frequency	11.0%	29.0%	0.18	163.6%
	Density	0.28	0.79	0.51	182.1%
	Dom. Val.	0.16	0.67	0.51	318.8%
Potamogeton pusillus	Frequency	5.0%	1.0%	-0.04	-80.0%
	Density	0.66	0.01	-0.65	-98.5%
	Dom. Val.	0.17	1.0%	-0.16	-94.1%
Potamogeton zosteriformis	Frequency	1.0%	3.0%	0.02	200.0%
	Density	0.03	0.03	0	0.0%
	Dom. Val.	0.02	0.04	0.02	100.0%
Vallisneria americana	Frequency	1.0%	3.0%	0.02	200.0%
	Density	0.05	0.06	0.01	20.0%
	Dom. Val.	0.02	0.06	0.04	200.0%
Zosterella dubia	Frequency	2.0%	2.0%	0	0.0%
	Density	0.05	0.02	-0.03	-60.0%
	Dom. Val.	0.03	0.03	0	0.0%
Calamagrostis canadensis	Frequency		1.63%	0.0163	100.0%
	Density		1.0%	0.01	100.0%
	Dom. Val.		0.01	0.01	100.0%
Carex crawfordii	Frequency		0.81%	0.0081	100.0%
	Density		0	0	
	Dom. Val.		0	0	
Carex comosa	Frequency		2.44%	0.0244	100.0%
	Density		0.02	0.02	100.0%
	Imp. Val.		0.02	0.02	100.0%
Eupatorium purpureum	Frequency		2.44%	0.0244	100.0%
	Density		0.02	0.02	100.0%
	Imp. Val.		0.02	0.02	100.0%

Hypericum canadense	Frequency		0.81%	0.0081	100.0%
	Density		0	0	
	Imp. Val.		0	0	
Iris versicolor	Frequency				
	Density		1.63%	0.0163	100.0%
	Imp. Val.		0.01	0.01	100.0%
			0.01	0.01	100.0%
Juncus	Frequency	1.67%	1.73%	0.0006	103.6%
	Density	0.03	0.01	-0.02	-66.7%
	Imp. Val.	.01	.01	0	0
Lathyrus palustris	Frequency		0.81%	0.0081	100.0%
	Density		0	0	0.0%
	Imp. Val.		0	0	0.0%
Nasturtium microphyllum	Frequency		2.44%	0.0244	100.0%
	Density		0.01	0.01	100.0%
	Imp. Val.		0.02	0.02	100.0%
Phalaris arundinacea	Frequency		4.88%	0.0488	100.0%
	Density		0.02	0.02	100.0%
	Imp. Val.		0.03	0.03	100.0%
Potamogeton illinoensis	Frequency		2.44%	0.0244	100.0%
	Density		0.01	0.01	100.0%
	Imp. Val.		0.01	0.01	100.0%
Ranunculus recurvatus	Frequency		0.81%	0.0081	100.0%
	Density		0	0	
	Imp. Val.		0	0	
Sagittaria	Frequency	1.67%	0.81%	-0.0086	-51.5%
	Density	0	0	0	0.0%
	Imp. Val.	0.02	0	-0.02	-100.0%

Salix	Frequency		0.81%	0.0081	48.5%
	Density		0	0	0.0%
	Imp. Val.		0	0	0.0%
Scirpus validus	Frequency		3.25%	0.0325	100.0%
	Density		0.01	0.01	100.0%
	Imp. Val.		0.02	0.02	100.0%
Thelpteris palustris	Frequency		0.81%	0.0081	100.0%
	Density		0	0	0.0%
	Imp. Val.		0	0	0.0%
Typha latifolia	Frequency		5.69%	0.0569	100.0%
	Density		0.02	0.02	100.0%
	Imp. Val.		0.03	0.03	100.0%
Eleocharia acicularis	Frequency	4.17%		-0.0417	-100.0%
	Density	0.05		-0.05	-100.0%
	Imp. Val.	0.03		-0.03	-100.0%
Nitella	Frequency	10%		-0.1	-100.0%
	Density	0.22		-0.22	-100.0%
	Imp. Val.	0.08		-0.08	-100.0%
Potamogeton foliosus	Frequency	10.83%		-0.1083	-100.0%
	Density	0.34		-0.34	-100.0%
	Imp. Val.	0.11		-0.11	-100.0%
Spirodela polyrhiza	Frequency	1.67%		-0.0167	-100.0%
	Density	0.01		-0.01	-100.0%
	Imp. Val.	0		0	0.0%

Of the species occurring in both years, all have decreased from 2000 to 2006, except the exotics, *Myriophyllum spicatum* and *Potamogeton crispus*, and the drawdown-tolerant *Potamogeton pectinatus, Potamogeton zosteriformiss* and *Vallisneria americana.*

V. CONCLUSIONS

Sherwood Lake is an eutrophic/mesotrophic impoundment with poor to fair water quality and poor water clarity. High disturbance is impacting the plant community as measured by the Average Coefficient of Conservatism and the Floristic Quality Index. The quality of the aquatic plant community is below average for both North Central Hardwood Region and all Wisconsin lakes as measured by the AMCI. Filamentous algae are present. Structurally, the aquatic plant community contains very few emergent plants and no floating-leaf rooted plants. Submergent plants dominate the aquatic plant community in this lake.

Vegetation of the littoral zone increased 54%, so that over 84% of the zone is now vegetated. The potential for plant growth at all depths of the lake is present, even with many of the lake sediments sand and the poor water clarity. This growth percent is at the top of the recommended vegetation percentage for healthiest fish population (50%-85%).

Potamogeton pectinatus was the most frequently-occurring plant in Sherwood Lake in 2006. In 2000, it was *Chara* spp. No species but *Potamogeton pectinatus* reached a frequency of 50% or greater in the lake overall in 2006, although *Chara spp* and *Potamogeton crispus* were not far under 50%, with occurrence frequencies of 45.53% and 42.28% respectively. *Potamogeton pectinatus* was also the densest plant in 2006 in Sherwood Lake. In the lake overall, none of the aquatic vegetation had a mean density of over 2.0, meaning none occurred at more than average density, in 2006. In 2006, the only species occurring at more than average density in any of the depth zones was *Potamgeton pectinatus* in the second (1.5'-5') and third (5'-10') depth zones. These figures indicate some areas of the lake have species with higher than average density that can interfere with fish habitat and recreational use.

A healthy and diverse aquatic plant community plays a vital role within the lake ecosystem. Plants help improve water quality by trapping nutrients, debris and pollutants in the water body; by absorbing and/or breaking down some pollutants; by reducing shore erosion by decreasing wave action and stabilizing shorelines and lake bottoms; and by tying-up nutrients that would otherwise be available for algae blooms. Aquatic plants provide valuable habitat resources for fish and wildlife, often being the base level for the multi-level food chain in the lake ecosystem, and also produce oxygen needed by animals.

Further, a healthy and diverse aquatic plant community can better resist the invasion of species (native and non-native) that might otherwise "take over" and create a lower quality aquatic plant community. A well-established and diverse plant community of natives can help check the growth of more tolerant (and less desirable) plants that would otherwise crowd out some of the more sensitive species, thus reducing diversity.

Vegetated lake bottoms support larger and more diverse invertebrate populations that in turn support larger and more diverse fish and wildlife populations (Engel, 1985). Also, a mixed stand of aquatic macrophytes (plants) supports 3 to 8 times more invertebrates and fish than do monocultural stands (Engel, 1990). A diverse plant community creates more microhabitats for the preferences of more species.

MANAGEMENT RECOMMENDATIONS

(1) Because the plant cover in the littoral zone of Sherwood Lake is at the top of the ideal (25%-85%) coverage for balanced fishery, continued harvesting to open fishing lanes could occur in some areas. Removal should occur by hand in the shallower areas to be sure that entire plants are removed and to minimize the amount of disturbance to the sediment.

(2) Natural shoreline restoration and erosion control in many areas is needed, especially on some bare steep banks. If trees fall at the eroded sites due to continued erosion, large portions of the banks will fall with them. Natural shoreline has decreased since 2000 and disturbed shoreline has increased, especially in hard structure and rock riprap.

(3) To protect water quality, a buffer area of native plants needs to be restored on those many sites that now have seawalls or have traditional lawns mowed to the water's edge. Most areas of the lake shoreline are unnatural and prone to erosion & runoff of nutrients & toxics. Unmowed native vegetation reduces runoff into the lake and filters runoff that enters the lake.

(4) The Tri-Lakes Management District and the Sherwood Lake Association should continue to cooperate with the WDNR to monitor for zebra mussel introduction to protect the aquatic plant community in Sherwood Lake.

(5) Studies indicate that properties around the lakeshore are putting nutrients into the lake, rather than most of the nutrients coming from the watershed. To improve the quality of the lake water and prevent further degradation:

   (a) Stormwater management of the many impervious surfaces around the lake is essential to improve the quality of the lake water and prevent further degradation.
   (b) No lawn chemicals should be used on properties around the lake. If they must be used, they should be used no closer than 50’ to the shore. Green grass tends to equal green lake.
   (c) The few sites where there is undisturbed shore should be maintained and left undisturbed.
   (d) Sherwood Lake residents should identify, cooperate with and participate in watershed programs that will reduce nutrient and sediment inputs.

(6) The aquatic plant management plan should be reviewed annually. Mechanical harvesting plans should continue target harvesting for Eurasian Watermilfoil (EWM) and include target harvesting for Curly-Lead Pondweed to prevent further spread.

(7) The Sherwood Lake Association may want to continue to apply for grants from the Wisconsin Department of Natural Resources to help defray the cost of aquatic plant management.

(8) No broad-scale chemical treatments of aquatic plant growth are recommended due to the undesirable side-effects of such treatments, including increased nutrients from decaying plant material and decreased dissolved oxygen and opening up more areas to the invasion of EWM.

(9) Any fallen trees should be left at the shoreline in the water for habitat.

(10) The Tri-Lakes Management District conducted limited water quality monitoring for several years, but has decreased its involvement during 2004-2006 when Adams Land & Water Conservation Department was doing more intense monitoring as part of a Lake Classification Grant. Monitoring by the Lake District or through the DNR Self-Help Monitoring Program should be restarted.

(11) No drawdowns of water level except for DNR-approved purposes should occur. Several of the plants found in Sherwood Lake in 2006 are those encouraged by drawdowns. In addition, water drawdowns are increasing the inflow of nutrient-rich groundwater into the lake.

(12) The Tri-Lakes Management District should make sure that its lake management plan takes into account all inputs from both the Sherwood Lake surface ground watershed and inputs from Camelot & Sherwood Lakes, and addresses the concerns of this larger lake community.

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